# Road Pricing: The Trade-Off Between Transportation Performance and Financial Feasibility

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## Abstract

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This study estimates the transportation performance and financial impacts of Express Toll (ET) lane and High Occupancy Toll (HOT) lane concepts, with and without new Bus Rapid Transit (BRT) service, as well as the Fast and Intertwined Regular (FAIR) highway concept. Estimates are made for a prototypical suburban transportation corridor in a *major* metro area, using the SMITE-ML model, which was enhanced to provide capability to analyze the conventional Build concept with no priced lanes and the FAIR highways concept that involves pricing all lanes.

The analysis demonstrates that, in a typical case, a HOT alternative may mitigate congestion more cost-effectively than an ET alternative. Combining BRT with ET may make this alternative much more effective, and may make it more effective than a HOT alternative with no BRT. BRT increases benefits and net present value of both ET and HOT alternatives, but reduces financial feasibility due to the need for public tax support for transit. The ET alternatives tend to be more financially feasible than HOT alternatives primarily due to the additional revenues generated from tolls since HOVs are not exempt. The conclusions appear to hold up under extreme assumptions with regard to demand elasticity and value of time. However, travel demand characteristics vary significantly from one large metro to another, and from one travel corridor to another. Therefore, it is necessary to re-run the SMITE-ML model with data from a specific corridor before definitive conclusions can be drawn about the impacts of pricing solutions in a specific corridor.

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## 1.0 INTRODUCTION

Interest in road pricing as a congestion management and revenue generating mechanism is increasing in the U.S. Two types of priced express lanes are under consideration in several metropolitan areas – HOT lanes and Express Toll lanes. "HOT" is the acronym for "High Occupancy/Toll." On HOT lanes, low occupancy vehicles are charged a toll, while High-Occupancy Vehicles (HOVs) are allowed free or discounted use. Generally, an HOV is defined as a vehicle carrying two or more persons. Tolls vary by time-of-day, either according to a pre-set schedule or in real time (i.e., "dynamically") in order to manage traffic demand and ensure free flow of traffic. Tolls are collected at highway speeds using electronic toll collection technology. Express Toll (ET) lanes operate in a similar fashion, the only difference being that HOVs are not exempt from tolls. Both types of priced lanes may be combined with new express bus services or Bus Rapid Transit (BRT) operating on the free flowing priced lanes. Public officials are interested in how these concepts compare with one another with regard to their congestion mitigation and financial implications.

This study estimates the impacts of ET and HOT concepts with and without new BRT service in a prototypical suburban transportation corridor in a major metro area, in order to facilitate an understanding of the trade-offs between transportation performance and financial feasibility with regard to such concepts.

## 2.0 PRICING CONCEPTS

The prototypical corridor is a major heavily congested suburban freeway travel corridor in a large metropolitan area in the Northeast. The corridor is 20 miles long, and 40% growth in travel demand is anticipated over a 20-year period. The existing freeway facility in the corridor has 8 lanes. Available right-of-way is only sufficient for expansion of the freeway by one added lane in each direction.

ET and HOT concepts selected for consideration include two priced lanes in each direction. Thus, they require taking one existing lane in each direction for use as a priced lane in conjunction with an added lane. ET and HOT concepts involving a *single* priced lane in each direction were excluded from consideration, for the following reasons. First, a single separated lane makes it impossible for a faster vehicle to overtake a slower vehicle. This can cause back-ups behind a slower vehicle, reducing the speed and level of service for those vehicles caught behind the slower vehicle. It may also lead to gaps in front of the slower vehicle, reducing lane throughput. Secondly, carpooling rates in major travel corridors in large metro areas are often forecasted to be high in future – high enough to fill up and even exceed the capacity of a single lane during peak periods. Thus, there would not be spare capacity available to "sell" to low-occupancy toll-paying vehicles. A single HOT lane would therefore not be feasible, unless vehicle occupancy requirements were raised above the currently prevailing requirements in most major metropolitan areas. Finally, in case of accidents and vehicle breakdowns, it would be easier to move traffic through a two-lane configuration than through a single lane configuration.

The ET and HOT concepts selected for consideration would divide the new 5-lane configuration in each direction into two sections - three regular lanes and two priced lanes. Free access would be provided for transit vehicles. Both concepts would utilize one new lane and take one existing lane for use as two priced lanes. Some have questioned public acceptability of such a concept in view of the failure of past attempts to take general-purpose lanes for restricted use. However, the ET concept analyzed for this study is quite different with regard to its effects. Since the freeway will be expanded, congestion will actually be reduced on the general-purpose (GP) lanes. Vehicle demand per lane will be lower than prior to expansion (i.e., the No Build case). This is very different from previous experiences, when more motorists were forced onto remaining GP lanes, *increasing* the number of vehicles that would need to be served per GP lane and thus exacerbating congestion.

Moreover, even if a freeway were not expanded, the establishment of *priced* lanes has a different effect than establishment of HOV lanes. HOV lanes are often underutilized. Priced lanes on the other hand are fully utilized and actually *increase* freeway vehicle throughput per lane in peak periods relative to throughput per lane on regular lanes. This occurs because of the loss of vehicle throughput in GP lanes due to severely congested conditions (1). Data from the SR 91 Express Toll Lanes in Orange County, CA indicate that vehicle throughput per lane on the ET lanes in peak hours in March 2004 was twice that on the adjacent regular lanes (2). Further, when taking GP lanes for use as priced lanes, surplus toll revenue may be generated. This surplus may be used to enhance transit or carpooling alternatives, further increasing freeway *person* throughput and reducing vehicular demand and congestion.

To ensure apples-to-apples comparisons of all pricing concepts, all alternatives considered in this study involve expansion of the freeway to 10 lanes. A No Build alternative (8 lanes) and a conventional Build alternative involving expansion to 10 free lanes (Alternative 1) are also considered for comparison. The ET alternatives (Alternatives 2 and 3) and HOT alternatives (Alternatives 4 and 5) reserve four of the 10 lanes (i.e., two in each direction) for use as priced lanes. Alternative 6 is a new concept called "Fast and Intertwined Regular" highways or FAIR highways. The FAIR concept involves pricing *all* freeway lanes while providing free HOV service, low-income motorist discounts, and low-fare/ high quality transit service with convenient park-and-ride access. The ET and HOT concepts are each analyzed in combination with two alternative transit policy packages, as follows:

- *"Low transit" policy package* (Alternatives 2 and 4): This policy would allow toll-free use of priced lanes by transit vehicles, but not provide funding for new express service or BRT service.
- *"High transit" policy package* (Alternatives 3 and 5): This policy would allow toll-free use of priced lanes by transit vehicles; provide funding for additional express bus or new BRT service sufficient to meet transit demand during peak periods at normal fares; and

provide new park-and-ride facilities at freeway access points in the residential areas of suburbs to further encourage transit use.

## 3.0 ANALYSIS PROCEDURES

All models have limitations and their results always contain uncertainties, no matter how sophisticated they may be. This is particularly true with regard to modeling of pricing policies. Pricing policies require extremely complicated modeling procedures. For accurate representation of travel behavior, they must use *distributions* of the value of travel time, rather than *average* values, as most four-step travel demand models do, even those that are highly advanced (3). The state of the practice with regard to modeling of pricing policies is in its infant stages. US DOT has only recently begun efforts to advance the state of the practice and state of the art. These efforts are not expected to bear fruit for several years. In the meantime, analysts seeking to evaluate pricing policies may consider using quick-response "sketch planning" tools such as SMITE-ML (4) or SPRUCE (5). Such models are generally transparent. Analysts can quickly understand how they work and the key parameters that cause them to produce the results that they do.

An enhanced version of the SMITE-ML model was used for this study. Since the model was designed for analysis of Managed Lane concepts, modifications had to be made to the model in order to provide capability to analyze the conventional Build concept with *no* priced lanes (Alternative 1) and the FAIR highways concept that involved pricing *all* lanes (Alternative 6). The enhanced model produces estimates of:

- *Travel demand impacts* (i.e., changes in modal shares for commuters, peak period and daily traffic on highway facilities in the travel corridor, HOV and toll-paying vehicle volumes, etc.);
- *Mobility impacts and toll revenues* (i.e., changes in travel delays, vehicle and person throughput, user costs for tolls, annual toll revenues, etc.);
- *Environmental costs* from vehicle operation, including the social costs or benefits of any changes in vehicular travel; and
- *Performance measures*, including measures of financial feasibility (e.g., excess of costs above revenues), economic efficiency (e.g., net present value) and cost-effectiveness (e.g., cost per hour of delay reduced, transit costs per new transit trip, highway costs per new person trip accommodated, etc.).

The enhanced SMITE-ML model used in this analysis may be downloaded from *http://knowledge.fhwa.dot.gov/* (Click on "Highway Community Exchange" on the right; then click on "Value Pricing" from the list at the bottom; then click on "Works in Progress"; then click on SMITE-ML 2.0)

SMITE-ML model inputs for the base case No Build alternative for the prototypical corridor were based on outputs from a four-step travel model run for the year 2020 using a model maintained by the Metropolitan Planning Organization (MPO) for the metro area. For the SMITE-ML model runs, the 20-mile corridor was divided into three segments based on differences in traffic volumes from one segment to the next.

## 4.0 TRAVEL IMPACTS

SMITE-ML uses a "pivot point" mode choice model (6) to estimate impacts of alternatives on peak period mode shares, pivoting off of estimated No Build mode share estimates. For each alternative, appropriate inputs were provided, as shown for one segment of the corridor in Table 1, to reflect differences in in-vehicle travel times, out-of-vehicle travel times and out-of-pocket costs for each mode relative to the No Build base case. For pricing alternatives, the solo-driver and carpool in-vehicle travel time inputs represent the combined effect of changes in both travel time and toll costs in terms of travel time. After completion of the SMITE-ML model runs, travel time outputs were compared with the travel time inputs to ensure that they were consistent. If inconsistent, adjustments were made to the inputs, and the model was run iteratively, until consistency was obtained. Table 2 presents the results for one of the three corridor segments, the southern segment (also identified as Segment 1).

Due to mode shifts to transit and carpooling, pricing alternatives tend to reduce vehicle demand relative to the base case No Build and conventional Build alternatives. However, the reduced vehicular demand and reduced congestion on regular lanes causes diversions of traffic *to* the freeway from other routes and destinations, and allows additional development to occur in the region with consequent new trips in the corridor, also known as "induced" trips. SMITE-ML estimates the increase in traffic and new person trips that result from mobility improvements.

Before estimating induced demand, SMITE-ML estimates traffic diverted from arterials to the expanded freeway by redistributing traffic such that relative levels of congestion on the freeway and the arterials stay the same. This technique is based on techniques used by practitioners in refining traffic forecasts from four-step models for project development (7). SMITE-ML then uses travel demand elasticities with respect to travel time, to estimate new travel that may be induced over and above traffic that is simply rerouted from other highways. This includes *new* trips generated or attracted to new development, and *existing* trips diverted from other destinations. (The mode choice model estimates *existing* trips that may be diverted to autos from other modes of travel such as transit.)

SMITE uses speed relationships developed by Margiotta *et al* (8) to estimate the effects of congestion on speeds. The Average Daily Traffic-to-Hourly Capacity ratio (ADT/HC) is a key variable used to predict congestion-related delays, where "HC" refers to two-way hourly capacity. Hourly capacities per lane vary based on number of concurrent flow lanes. Capacities from the Highway Capacity Manual (9) were used to calculate hourly capacities on the GP and priced sections of the freeway. For priced lanes, it is assumed that variable pricing will dampen peak vehicle demand to maintain free-flow speeds in the peak periods. Toll rates would be set dynamically to keep average demand on the priced lanes at 0.75 times capacity for two priced lanes per direction, and 0.85 times capacity for five priced lanes per direction (i.e., for the FAIR highways alternative) due to the greater freedom to switch lanes with five concurrent lanes.

An elasticity of demand with respect to travel time of –0.2 was assumed. To test the sensitivity of analysis results to this elasticity assumption, the model was run with a low-end estimate (50% lower) of –0.1 and a high-end estimate (50% higher) of –0.3. These demand elasticities are relatively lower than commonly found in the literature (10). They reflect the paucity of vacant land available for increased development in already developed freeway corridors in major urban areas, the large proportion of relatively short trips, as well as the fact that mode choice changes which might contribute to induced travel are already accounted for using pivot point mode choice analysis.

Induced demand is estimated for the general-purpose lanes only. By iteratively estimating induced travel demand on GP lanes and the resulting travel time "price" change, an equilibrium point is found at which demand and price are in balance, using a series of equations (11) approximating the equilibration process. With regard to priced lanes, the mode choice model already estimates induced carpool usage, and solo-driver demand in peak hours is assumed to fully utilize the balance of available capacity up to the service volume thresholds set to ensure free flow of traffic. Peak period HOV use on the HOT lanes was estimated assuming that 90% of HOV demand estimated by the mode choice model would use the lanes. Single-occupant vehicle (SOV) volumes on HOT lanes were estimated to be equal to the spare vehicle capacity that would be available on the lanes. The diverted and induced traffic estimates for the alternatives for the southern corridor segment are presented in Table 3.

## 5.0 TOLL REVENUES AND OPERATION COSTS

The average toll rate per mile was estimated based on average time saved per mile by vehicles in the priced lanes relative to GP lanes. Time saved is converted into a monetary value, using the "minimum" value of time of toll-payers. This value is equivalent to the toll that the "marginal" solo-driving motorist who chooses the priced lanes (and values his or her time the least among all priced lane users) would be willing to pay. For example, commuters in the toll lanes in the median of SR 91 in Orange County, CA value their time at a minimum of $13 to $16 per hour (12). The analysis assumed a value of $14 per hour for the two HOT alternatives and $13 per hour for the two ET alternatives. Since more toll-paying motorists will use ET lanes than HOT lanes, the minimum value of time of such motorists will be lower than that for the HOT alternatives. For the FAIR alternative, all motorists using the freeway other than HOVs will pay the toll. Therefore, the minimum value of time of toll-paying motorists was assumed to be $3 per hour, i.e., about 50% of the minimum wage rate.

These assumed values are critical in estimating toll revenues for financial analysis. It is therefore essential that they be verified through stated preference surveys or other means to ensure greater accuracy. To test the sensitivity of the model's estimates to these assumptions, the model was run with low-end estimates (50% lower) of $7, $6.50 and $1.50 per person hour respectively, and high-end estimates (50% higher) of $21, $19.50 and $4.50 respectively.

Annual revenues are estimated based on tolls charged on 250 working weekdays a year, supplemented by week-end and holiday revenues amounting to an additional 10 percent. For the FAIR alternative, a 10 percent reduction in revenue was assumed in order to account for low-income motorist discounts.

The SMITE-ML model estimates costs for toll operations, based on an electronic toll collection cost of 10 cents per trip and an average priced trip distance of 5 miles on tolled segments. The model also estimates new transit subsidies that would be needed to support additional transit service above the No Build case. BRT subsidies were estimated at 50 cents per passenger mile, based on nationwide subsidies of $23.5 billion supporting 50 billion passenger miles annually (13). Results from the model showing highway and transit impacts for the southern corridor segment are presented in Tables 4 and 5.

## 6.0 SOCIETAL COSTS AND BENEFITS

A major portion of traveler benefits is the reduction in travel time. The value of travel time savings is estimated for both "previous" travelers as well as diverted or "induced" travelers. For "induced" trips, the rule of half is used to estimate consumer surplus. The conversion of time savings to a monetary value is based on an *average* value of time of $9.00 per person hour based on estimates by US DOT (14). The parameter is critical in estimating traveler benefits for economic analysis. Sensitivity of model results to this critical value of time assumption was tested using a low-end estimate (50% lower) of $4.50 per person hour and a high-end estimate (50% higher) of $13.50 per person hour.

In addition to the value of travel time saved by reduced delays, motorists save fuel as a result of reduced accelerations and decelerations. FHWA's Highway Economic Requirements System (HERS) model (15) estimates fuel consumption in relation to speeds. Based on the HERS model equations, ECONorthwest (16) calculated excess fuel consumed per minute of delay. On a facility with a free-flow speed of 60 mph, excess fuel consumed ranges from 0.037 gallons per minute of delay for a small car to 0.073 gallons per minute of delay for a sports utility vehicle (SUV). This equates to an added fuel cost (inclusive of fuel taxes) of about 10 cents per minute of delay assuming about $2.00 per gallon at the pump. Since fuel taxes are a transfer, savings to motorists are losses to government agencies, and there is no net change in societal benefit from gas tax savings. Therefore, in computing societal benefits for the alternatives, changes in fuel taxes are ignored. After subtracting State and Federal fuel taxes, fuel costs amount to 8 cents per minute of delay, or $4.80 per vehicle hour of delay. Assuming average vehicle occupancy of 1.33, travel time delay costs amount to $12.00 per vehicle hour (i.e., $9.00 per person hour X $1.33). Thus, fuel consumption costs from delay amount to about 40% of travel time delay costs.

Motorists may have fewer accidents when congestion delay is reduced. For example, experience with the toll lanes on SR 91 suggests that there has been a reduction in accidents on the entire facility as a result of pricing (12). However, other research suggests that the likelihood of fatalities increases with higher highway speeds. Due to lack of definitive data, possible changes in crash costs have been ignored for this analysis.

Travelers will be subjected to extra delays during project construction. The model estimates excess delay due to construction activities. It assumes that delays would increase by 100%, over a period of 250 construction days (4). The change in external costs (including air pollution, noise and crashes) due to changes in traffic relative to the No Build alternative were estimated using an average cost of 6 cents per vehicle mile. This cost per vehicle mile was calculated based on the low-range nationwide estimates of these costs, amounting to $153.7 billion, and nationwide vehicle miles of travel amounting to 2.7 trillion in the year 2000 (17).

The estimated excess travel delay costs during project construction and changes in external costs relative to the No Build alternative were combined with estimates of user benefits (i.e., time and fuel savings) to get net annual benefits. The present value of benefits over a 30-year period was estimated assuming a 7% discount rate (18). Results from the model showing estimates of societal benefits and costs for the southern segment of the corridor are presented in Tables 6 and 7.

## 7.0 PERFORMANCE AND FINANCIAL IMPLICATIONS

Tables 8 and 9 present key model outputs for the six alternatives. The Tables summarize all three corridor segments combined. Table 10 presents the results of the various sensitivity tests for the effects of demand elasticity and value of time assumptions.

The results shown in Table 8 suggest that FAIR and HOT alternatives that include BRT may be superior to ET lane alternatives (with or without BRT) from a *mobility* standpoint. They reduce delay more effectively, as may be seen by the estimates of the number of person hours of delay reduced daily (bottom line). Table 9 suggests that encouraging competing modes such as HOV and transit on priced lanes can negatively impact the magnitude of toll revenues. There are far fewer toll-paying vehicles if HOVs are not required to pay a toll. Also, because congestion is reduced on general-purpose lanes as drivers shift to alternative modes, this reduces the magnitude of the toll rates that the remaining low-occupancy vehicle drivers are willing to pay for use of the priced lanes. For the FAIR alternative, toll rates are lowest due to the much larger "supply" of priced road space (i.e., five lanes vs. two for the priced alternatives). Discounts for low-income motorists require a further adjustment of toll revenue estimates. However, three more lanes are tolled, and congestion is relatively higher on alternative free routes (i.e., the arterials) increasing willingness to pay. Consequently revenues still exceed those for ET and HOT alternatives.

Highway cost estimates shown in Table 9 are based on FHWA construction cost data (15) and data from planning studies and actual costs from projects implemented under FHWA's Value Pricing Pilot Program. The following cost parameters were derived:

- $10 million per lane mile for added lanes
- $2 million per mile of lane separation with priced lanes, including extra pavement width
- Interchange modification costs at an average of $20 million per freeway mile
- Direct connector ramp costs at $10 million per freeway mile, assuming ramps are needed every two or three miles, for priced lane alternatives only
- Toll collection equipment costs (including vehicle transponder costs) averaging $1 million per mile for ET and HOT alternatives, and $2 million per mile for the FAIR alternative
- Freeway added maintenance costs of $50,000 per added lane mile per year.
- HOV enforcement costs of $100,000 per mile per year for HOT and FAIR alternatives.

Note that annual toll collection operation costs are calculated based on number of tolled trips, as discussed in Section 5. Interestingly, the added HOV enforcement costs for HOT lanes (i.e., $2 million per year for 20 miles) are comparable to the additional annual toll collection costs for ET lanes of about $1.6 million due to more toll-paying vehicles on ET lanes. The results in Table 9 suggest that all pricing alternatives are more financially feasible than the conventional Build alternative, due to the additional revenues generated from tolls. ET and FAIR alternatives are superior to HOT alternatives from the standpoint of *financial feasibility*. An ET or HOT alternative that is combined with BRT has the ability to support higher levels of mobility and larger numbers of person trips, thus generating greater *economic* benefits. However, the "downside" is that priced lanes with BRT are less financially feasible because of the high costs for new transit service. Also, when trips are shifted to transit higher levels of mobility exist in the "free" lanes, reducing the price that motorists are willing to pay for premium service and therefore toll revenue.

The section on "performance measures" in Table 9 organizes the key benefit-cost information relevant to the investment and policy decisions. It shows estimates of the present value of a stream of aggregate social benefits and a stream of public infrastructure and operation costs (for both highways and transit) for a 30-year period. The present value of public costs is subtracted from the present value of benefits to get net present value (NPV).

All alternatives demonstrate significant positive NPVs, even under extreme assumptions of elasticity and value of time, as shown in Table 10. While the ET alternative without BRT generates significant positive NPVs under all assumptions, these values are generally somewhat lower than the comparable HOT alternative with the same transit policy package, even when assumed values of time are extremely low. When BRT is added to the ET and HOT alternatives, their NPVs increase relative to the same alternatives without BRT. The FAIR alternative generates the highest NPV. For decision-making, these benefit-cost analysis results must, of course, be augmented with consideration of other factors, like public concerns and the equitable distribution of benefits.

Table 9 also presents effectiveness and cost-effectiveness with regard to congestion mitigation. The HOT alternatives are more effective than ET alternatives with a comparable transit policy with regard congestion mitigation (see person hours of delay reduced). Despite the higher annual costs for HOV enforcement, HOT cost-effectiveness (i.e., costs per hour of delay reduced) is also higher when alternatives with similar transit policies are compared. The last measure of effectiveness, "new person trips accommodated" attempts to measure the effectiveness of the alternatives with regard to generating new development. Those alternatives that allow more person trips to be served (e.g., the conventional Build alternative) fare better according to this measure. This suggests that road pricing may be beneficial to commuters and other travelers, but may adversely affect development interests.

The sensitivity analysis results (Table 10) suggest that extreme demand elasticity assumptions can cause as much as a 100 percent difference in the number of induced highway trips. However, the effects of these differences on the economic efficiency indicator (i.e., NPV) are small for the pricing alternatives, although they are significant for the conventional Build alternative. With fewer induced trips (i.e., lower demand elasticity), higher NPV is attained, due to reduced congestion. Higher congestion levels on GP lanes caused by more induced trips also result in higher toll rates on priced lanes, and therefore additional toll revenue, with about a 5 to

10 percent difference in revenue for a 100 percent difference in the number of induced highway trips.

Value of time assumptions can have significant effects on both toll revenue estimates as well as NPV estimates. Because time savings are such a large part of economic benefits (about 70 percent), there are very large variations in resulting NPV estimates. There is a one-to-one relationship between *toll-paying* motorists' minimum value of time and toll revenues, with a 50 percent difference in assumed value producing a 50 percent difference in toll revenue.

The analysis suggests that FAIR highways may be the best choice from the point of view of congestion mitigation, economic efficiency, and financial feasibility. However, since public acceptance will be a major hurdle, the second best choices, from the point of view of congestion mitigation and economic efficiency, are HOT lanes with BRT. If HOV enforcement is an issue, ET lanes with BRT may be the next best choice. If public tax support cannot be obtained for new BRT service and revenue uncertainty is an issue, ET lanes without BRT would be the next best choice. These conclusions must, of course, be augmented with consideration of factors in the decision-making process, such as other local community objectives, public concerns and the equitable distribution of benefits.

## 8.0 CONCLUSIONS

The analysis has demonstrated that, in a typical case, a HOT alternative may mitigate congestion more cost-effectively than an ET alternative. Combining BRT with ET may make this alternative much more effective, and may make it more effective than a HOT alternative with no BRT. BRT increases benefits and net present value of both ET and HOT alternatives, but reduces financial feasibility due to the need for public tax support for transit. The ET alternatives tend to be more financially feasible than HOT alternatives primarily due to the additional revenues generated from tolls since HOVs are not exempt. The conclusions appear to hold up under extreme assumptions with regard to demand elasticity and value of time. However, travel demand characteristics vary significantly from one large metro to another, and from one travel corridor to another. Therefore, it is necessary to re-run the SMITE-ML model with data from a specific corridor before definitive conclusions can be drawn about the impacts of pricing solutions in a specific corridor.

Results from the sensitivity analysis suggest that demand elasticity assumptions do not have a major effect on the magnitude of economic benefits for pricing alternatives, although effects on toll revenue may be significant due to higher toll rates resulting from the congestion effects of induced traffic on toll-free lanes. Value of time assumptions do have significant impacts on estimates of both economic benefits and toll revenues. For toll revenue estimates, there is a one-to-one correspondence, suggesting that, to be credible, any financial analysis will need to pay close attention to obtaining precise estimates of this parameter.



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**TABLE 1. MODEL INPUTS**

**SOUTHERN SEGMENT**

| | |
|---|---|
| **Length** | **9.00** |

| | No Build |
|---|---|
| **Travel demand and highway capacity:** | 0 |
| Total daily person trips | 445,000 |
| Percent in peak periods | 0.50 |
| Transit mode share | 0.04 |
| Bus occupancy (avg.) | 20 |
| Avg. auto occupancy | 1.10 |
| Avg carpool occupancy | 2.20 |
| Off-peak avg. auto ccupancy | 1.60 |
| Percent of traffic volume on freeways | 84.00% |
| Freeway capacity per lane (vph) | 2,370 |
| Number of restricted freeway lanes | 8 |
| Total arterial capacity (vph) | 4,000 |

| | No 1<br>10 GP Ln | No 2<br>4 ET | No 3<br>4 E + BRT | No 4<br>4 HOT | No 5<br>4 H+ BRT | No 6<br>10 H + BRT |
|---|---|---|---|---|---|---|
| Change in in-vehicle time | 0 | 0 | 0 | 0 | 0 | 0 |
| Solo driver | -6.9 | -7.9 | -7.7 | -6 | -7 | -21 |
| Carpool | -6.9 | -7.9 | -7.7 | -30 | -30 | -30 |
| Transit | -6.9 | -15 | -30 | -15 | -30 | -30 |
| | | | | | | |
| Change in out-of-vehicle times (min) | 0 | 0 | 0 | 0 | 0 | 0 |
| Solo driver | 0 | 0 | 0 | 0 | 0 | 0 |
| Carpool | 0 | 0 | 0 | 0 | 0 | 0 |
| Transit | 0 | 0 | -5 | 0 | -5 | -5 |
| | | | | | | |
| Change in out-of-pocket costs (cents) | 0 | 0 | 0 | 0 | 0 | 0 |
| Solo driver | 0 | 0 | 0 | 0 | 0 | 0 |
| Carpool | 0 | 0 | 0 | 0 | 0 | 0 |
| Transit | 0 | 0 | 0 | 0 | 0 | -100 |
| | | | | | | |
| Freeway capacity per lane - managed lanes (vph) | 2,280 | 2,280 | 2,280 | 2,280 | 2,280 | 2,400 |
| Freeway capacity per lane- GP lanes(vph) | 2,400 | 2,310 | 2,310 | 2,310 | 2,310 | 2,280 |
| Number of restricted freeway lanes | 0 | 4 | 4 | 4 | 4 | 10 |
| Number of GP lanes | 10 | 6 | 6 | 6 | 6 | 0 |
| % of capacity used at LOS C (free-flow) | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.85 |
| | | | | | | |
| **Transit costs:** | | | | | | |
| Transit subsidy per passenger mile | $0.50 | $0.50 | $0.50 | $0.50 | $0.50 | $0.50 |
| Cost per passenger mile for low fare service | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.20 |
| | | | | | | |
| **Highway costs (million $):** | | | | | | |
| Construction cost per added lane mile | $10.00 | $10.00 | $10.00 | $10.00 | $10.00 | $10.00 |
| Construction cost per mile of lane separation | $0.00 | $2.00 | $2.00 | $2.00 | $2.00 | $0.00 |
| Interchange modification costs per mile | $20.00 | $20.00 | $20.00 | $20.00 | $20.00 | $20.00 |
| Direct connector ramp const cost per mile | $0.00 | $10.00 | $10.00 | $10.00 | $10.00 | $0.00 |
| Toll collection equipment cost per mile | $0.00 | $1.00 | $1.00 | $1.00 | $1.00 | $2.00 |
| Total capital cost per mile | $40.00 | $55.00 | $55.00 | $55.00 | $55.00 | $42.00 |
| | | | | | | |
| Annual maintenance costs per added lane mile | $0.05 | $0.05 | $0.05 | $0.05 | $0.05 | $0.05 |
| Annual law enforcementcosts per mile | $0.00 | $0.00 | $0.00 | $0.10 | $0.10 | $0.10 |
| Discount factor for 7% discount rate/30-year payback | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 |
| Annualized highway cost per mile | $3.32 | $4.53 | $4.53 | $4.63 | $4.63 | $3.58 |
| Present value of highway costs | $371.17 | $506.17 | $506.17 | $517.34 | $517.34 | $400.34 |
| | | | | | | |
| **User and external benefits:** | | | | | | |
| No. of construction days | 250 | 250 | 250 | 250 | 250 | 250 |
| % increase in delays due to construction | 100% | 100% | 100% | 100% | 100% | 100% |
| Fuel cost per gallon excluding taxes | $1.60 | $1.60 | $1.60 | $1.60 | $1.60 | $1.60 |
| External cost per VMT($) | $0.06 | $0.06 | $0.06 | $0.06 | $0.06 | $0.06 |

**TABLE 2. TRAVEL DEMAND ESTIMATES FOR SOUTHERN SEGMENT OF TRAVEL CORRIDOR - YR 2020**

| | No Build | No 1<br>10 GP Ln | No 2<br>4 ET | No 3<br>4 E + BRT | No 4<br>4 HOT | No 5<br>4 H+ BRT | No 6<br>10 H + BRT |
|---|---|---|---|---|---|---|---|
| Total daily person trips | 445,000 | 445,000 | 445,000 | 445,000 | 445,000 | 445,000 | 445,000 |
| Total initial daily vehicle trips | 333,689 | 333,689 | 332,752 | 326,955 | 325,642 | 320,853 | 324,877 |
| | | | | | | | |
| Peak period mode shares: | | | | | | | |
| (prior to induced travel) | | | | | | | |
| Solo driver | 80.00% | 80.00% | 79.59% | 77.06% | 73.58% | 71.71% | 75.18% |
| Carpool | 16.00% | 16.00% | 15.92% | 15.41% | 22.13% | 21.20% | 17.52% |
| Transit | 4.00% | 4.00% | 4.49% | 7.52% | 4.29% | 7.08% | 7.29% |
| | | | | | | | |
| Peak period person trips: | | | | | | | |
| (prior to induced travel) | | | | | | | |
| Solo driver | 178,000 | 178,000 | 177,091 | 171,467 | 163,720 | 159,557 | 167,281 |
| Carpool | 35,600 | 35,600 | 35,418 | 34,293 | 49,241 | 47,180 | 38,987 |
| Transit | 8,900 | 8,900 | 9,990 | 16,739 | 9,539 | 15,763 | 16,231 |
| Total | 222,500 | 222,500 | 222,500 | 222,500 | 222,500 | 222,500 | 222,500 |
| | | | | | | | |
| Induced vehicle trips | 0 | 23,169 | 5,237 | 6,687 | 7,024 | 8,277 | -113 |
| Total daily vehicle trips | 333,689 | 356,859 | 337,989 | 333,642 | 332,665 | 329,131 | 324,764 |
| | | | | | | | |
| Freeway daily vehicle trips | 280,299 | 312,210 | 288,765 | 285,494 | 284,761 | 282,117 | 269,465 |
| Arterial daily vehicle trips | 53,390 | 44,648 | 49,224 | 48,148 | 47,904 | 47,014 | 54,288 |

**TABLE 3. YR 2020 ESTIMATES OF DIVERTED AND INDUCED TRAFFIC FOR SOUTHERN SEGMENT**

| | Alternative 1 | | | Alternative 2 | | | Alternative 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP | Toll | Total | GP | Toll | Total | GP | Toll | Total |
| Freeway: | | | | | | | | | |
| Initial traffic volume | 280,299 | 0 | 280,299 | 182,336 | 97,026 | 279,362 | 176,538 | 97,026 | 273,564 |
| Diverted traffic volume | 9,745 | 0 | 9,745 | 4,665 | 0 | 4,665 | 5,863 | 0 | 5,863 |
| Induced traffic volume | 22,166 | 0 | 22,166 | 4,738 | 0 | 4,738 | 6,066 | 0 | 6,066 |
| Total traffic volume after improvement | 312,210 | 0 | 312,210 | 191,739 | 97,026 | 288,765 | 188,467 | 97,026 | 285,494 |
| Percent change in traffic volume | 11.38% | 0.00% | 11.38% | 5.16% | 0.00% | 3.37% | 6.76% | 0.00% | 4.36% |
| Arterials: | | | | | | | | | |
| Initial traffic volume | 53,390 | | | 53,390 | | | 53,390 | | |
| Diverted traffic volume | (9,745) | | | (4,665) | | | (5,863) | | |
| Induced traffic volume | 1,003 | | | 499 | | | 621 | | |
| Total traffic volume after improvement | 44,648 | | | 49,224 | | | 48,148 | | |
| Percent change in traffic volume | -16.37% | | | -7.80% | | | -9.82% | | |
| Corridorwide: | | | | | | | | | |
| Initial traffic volume | 333,689 | 0 | 333,689 | 235,726 | 97,026 | 332,752 | 229,928 | 97,026 | 326,955 |
| Diverted traffic volume | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Induced traffic volume | 23,169 | 0 | 23,169 | 5,237 | 0 | 5,237 | 6,687 | 0 | 6,687 |
| Total traffic volume after improvement | 356,859 | 0 | 356,859 | 240,963 | 97,026 | 337,989 | 236,616 | 97,026 | 333,642 |
| Percent change in traffic volume | 6.94% | 0.00% | 6.94% | 2.22% | 0.00% | 1.57% | 2.91% | 0.00% | 2.05% |

| | Alternative 4 | | | Alternative 5 | | | Alternative 6 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP | Toll | Total | GP | Toll | Total | GP | Toll | Total |
| Freeway: | | | | | | | | | |
| Initial traffic volume | 175,225 | 97,026 | 272,251 | 170,437 | 97,026 | 267,463 | 0 | 270,476 | 270,476 |
| Diverted traffic volume | 6,134 | 0 | 6,134 | 7,124 | 0 | 7,124 | 0 | (1,011) | (1,011) |
| Induced traffic volume | 6,375 | 0 | 6,375 | 7,530 | 0 | 7,530 | 0 | 0 | 0 |
| Total traffic volume after improvement | 187,735 | 97,026 | 284,761 | 185,091 | 97,026 | 282,117 | 0 | 269,465 | 269,465 |
| Percent change in traffic volume | 7.14% | 0.00% | 4.59% | 8.60% | 0.00% | 5.48% | 0.00% | -0.37% | -0.37% |
| Arterials: | | | | | | | | | |
| Initial traffic volume | 53,390 | | | 53,390 | | | 53,390 | | |
| Diverted traffic volume | (6,134) | | | (7,124) | | | 1,011 | | |
| Induced traffic volume | 648 | | | 748 | | | (113) | | |
| Total traffic volume after improvement | 47,904 | | | 47,014 | | | 54,288 | | |
| Percent change in traffic volume | -10.28% | | | -11.94% | | | 1.68% | | |
| Corridorwide: | | | | | | | | | |
| Initial traffic volume | 228,615 | 97,026 | 325,642 | 223,827 | 97,026 | 320,853 | 53,390 | 270,476 | 323,866 |
| Diverted traffic volume | 0 | 0 | 0 | 0 | 0 | 0 | 1,011 | (1,011) | 0 |
| Induced traffic volume | 7,024 | 0 | 7,024 | 8,277 | 0 | 8,277 | (113) | 0 | (113) |
| Total traffic volume after improvement | 235,639 | 97,026 | 332,665 | 232,104 | 97,026 | 329,131 | 54,288 | 269,465 | 323,753 |
| Percent change in traffic volume | 3.07% | 0.00% | 2.16% | 3.70% | 0.00% | 2.58% | 1.68% | 0.00% | -0.03% |

**TABLE 4. YR 2020 HIGHWAY AND TRANSIT IMPACTS FOR SOUTHERN SEGMENT**

| | Alternative 1 | | | Alternative 2 | | | Alternative 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP | Toll | Total | GP | Toll | Total | GP | Toll | Total |
| Freeway: | | | | | | | | | |
| Initial speed before improvement (mph) | 23.18 | 23.18 | | 23.18 | 23.18 | | 23.18 | 23.18 | |
| Final speed after improvement (mph) | 30.29 | 60.00 | | 26.54 | 60.00 | | 27.53 | 60.00 | |
| Arterials: | | | | | | | | | |
| Initial speed before improvement (mph) | 12.03 | | | 12.03 | | | 12.03 | | |
| Final speed after improvement (mph) | 14.65 | | | 13.27 | | | 13.60 | | |
| Travel delay reduced (person hours per day) | | | | | | | | | |
| Freeway, previous users | 4,341 | 0 | | 1,425 | 4,334 | | 1,745 | 4,477 | |
| Freeway diverted users | 75 | 0 | | 18 | 0 | | 29 | 0 | |
| Freeway, induced users | 172 | 0 | | 19 | 0 | | 30 | 0 | |
| Arterial, previous users | 866 | 0 | | 454 | 0 | | 548 | 0 | |
| Arterial, induced users | 10 | 0 | | 2 | 0 | | 4 | 0 | |
| GRAND TOTAL | 5,463 | 0 | 5,463 | 1,918 | 4,334 | 6,252 | 2,355 | 4,477 | 6,832 |
| Value of time savings per day at VOT/hrer hı | **$9.00** | $9.00 | | $9.00 | $9.00 | | $9.00 | $9.00 | |
| Freeway, previous users | $39,068 | $0 | | $12,823 | $39,009 | | $15,701 | $40,295 | |
| Freeway diverted users | $679 | $0 | | $164 | $0 | | $261 | $0 | |
| Freeway, induced users | $1,545 | $0 | | $167 | $0 | | $270 | $0 | |
| Arterial, previous users | $7,790 | $0 | | $4,086 | $0 | | $4,933 | $0 | |
| Arterial, induced users | $90 | $0 | | $21 | $0 | | $32 | $0 | |
| GRAND TOTAL | $49,171 | $0 | $49,171 | $17,260 | $39,009 | $56,269 | $21,197 | $40,295 | $61,492 |
| Toll revenues and tolling operations costs | | | | | | | | | |
| Travel time per mile (min.) | 1.98 | 1.00 | | 2.26 | 1.00 | | 2.18 | 1.00 | |
| Time saved on restricted lanes (min/mile) | | 0.98 | | | 1.26 | | | 1.18 | |
| Minimum value of time per person hour of toll payers | | **$0.00** | | | **$13.00** | | | **$13.00** | |
| Value of time saved on priced lanes ($/mile) | | $0.00 | | | $0.27 | | | $0.26 | |
| Number of vehicles paying a toll in peak hours | | 0 | | | 54,220 | | | 53,883 | |
| Number of vehicles paying a tollb in off-peak hours | | 0 | | | 42,306 | | | 42,306 | |
| Total daily revenues per mile | | $0 | | | $26,375 | | | $24,584 | |
| Number of miles of facility | | **9.00** | | | **9.00** | | | **9.00** | |
| Total daily revenues | | $0 | | | $237,377 | | | $221,252 | |
| Number of working days per year | | 250 | | | 250 | | | 250 | |
| Gross annual revenues assuming 10% additional revenue f | | $0 | | | $65,278,626 | | | $60,844,290 | |
| Annual operation costs for tolling at 10cents per 5 mi. trip | | $0 | | | $1,737,483 | | | $1,731,409 | |
| Transit service costs | | | | | | | | | |
| New transit trips | | 0 | | | 1,090 | | | 7,839 | |
| Transit subsidy per passenger mile | | **$0.50** | | | **$0.50** | | | **$0.50** | |
| Annual subsidy for entire facility | | $0 | | | $1,226,793 | | | $8,819,226 | |
| Cost per passenger mile for low fare service | | **$0.00** | | | **$0.00** | | | **$0.00** | |
| Annual cost for entire facility for fare-free service | | $0 | | | $0 | | | $0 | |

**TABLE 5. YR 2020 HIGHWAY AND TRANSIT IMPACTS FOR SOUTHERN SEGMENT**

| | Alternative 4 | | | Alternative 5 | | | Alternative 6 | | |
|---|---|---|---|---|---|---|---|---|---|
| Travel speeds (mph) | GP | Toll | Total | GP | Toll | Total | GP | Toll | Total |
| Freeway: | | | | | | | | | |
| Initial speed before improvement (mph) | 23.18 | 23.18 | | 23.18 | 23.18 | | 23.18 | 23.18 | |
| Final speed after improvement (mph) | 27.76 | 60.00 | | 28.62 | 60.00 | | 0.00 | 60.00 | |
| Arterials: | | | | | | | | | |
| Initial speed before improvement (mph) | 12.03 | | | 12.03 | | | 12.03 | | |
| Final speed after improvement (mph) | 13.67 | | | 13.94 | | | 11.77 | | |
| Travel delay reduced (person hours per day) | | | | | | | | | |
| Freeway, previous users | 1,911 | 4,119 | | 2,165 | 4,249 | | 0 | 9,832 | |
| Freeway diverted users | 33 | 0 | | 45 | 0 | | 0 | -18 | |
| Freeway, induced users | 35 | 0 | | 48 | 0 | | 0 | 0 | |
| Arterial, previous users | 599 | 0 | | 671 | 0 | | -138 | 0 | |
| Arterial, induced users | 4 | 0 | | 5 | 0 | | 0 | 0 | |
| GRAND TOTAL | 2,582 | 4,119 | 6,701 | 2,935 | 4,249 | 7,184 | -138 | 9,814 | 9,676 |
| Value of time savings per day at VOT/hrer hı | **$9.00** | $9.00 | | $9.00 | $9.00 | | $9.00 | $9.00 | |
| Freeway, previous users | $17,201 | $37,072 | | $19,484 | $38,239 | | $0 | $88,492 | |
| Freeway diverted users | $301 | $0 | | $407 | $0 | | $0 | ($165) | |
| Freeway, induced users | $313 | $0 | | $430 | $0 | | $0 | $0 | |
| Arterial, previous users | $5,388 | $0 | | $6,043 | $0 | | -$1,242 | $0 | |
| Arterial, induced users | $37 | $0 | | $49 | $0 | | $1 | $0 | |
| GRAND TOTAL | $23,241 | $37,072 | $60,313 | $26,413 | $38,239 | $64,653 | -$1,241 | $88,326 | $87,086 |
| Toll revenues and tolling operations costs | | | | | | | | | |
| Travel time per mile (min.) | 2.16 | 1.00 | | 2.10 | 1.00 | | 5.10 | 1.00 | |
| Time saved on restricted lanes (min/mile) | | 1.16 | | | 1.10 | | | 4.10 | |
| Minimum value of time per person hour of toll payers | | **$14.00** | | | **$14.00** | | | **$3.00** | |
| Value of time saved on priced lanes ($/mile) | | $0.27 | | | $0.26 | | | $0.20 | |
| Number of vehicles paying a toll in peak hours | | 34,099 | | | 34,631 | | | 144,667 | |
| Number of vehicles paying a tollb in off-peak hours | | 42,306 | | | 42,306 | | | 107,276 | |
| Total daily revenues per mile | | $20,706 | | | $19,682 | | | $51,644 | |
| Number of miles of facility | | **9.00** | | | **9.00** | | | **9.00** | |
| Total daily revenues | | $186,352 | | | $177,142 | | | $464,794 | |
| Number of working days per year | | **250** | | | **250** | | | **250** | |
| Gross annual revenues assuming 10% additional revenue f | | $51,246,759 | | | $48,713,982 | | | $127,818,440 | |
| Annual operation costs for tolling at 10cents per 5 mi. trip | | $1,375,298 | | | $1,384,873 | | | $4,534,970 | |
| Transit service costs | | | | | | | | | |
| New transit trips | | 639 | | | 6,863 | | | 7,331 | |
| Transit subsidy per passenger mile | | **$0.50** | | | **$0.50** | | | **$0.50** | |
| Annual subsidy for entire facility | | $719,268 | | | $7,720,959 | | | $8,247,763 | |
| Cost per passenger mile for low fare service | | **$0.00** | | | **$0.00** | | | **$0.20** | |
| Annual cost for entire facility for fare-free service | | $0 | | | $0 | | | $3,299,105 | |

TABLE 6. ESTIMATES OF BENEFITS AND COSTS FOR SOUTHERN SEGMENT

| | Alternative 1 | | | Alternative 2 | | | Alternative 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP | Toll | Total | GP | Toll | Total | GP | Toll | Total |
| Travel delay costs per mile during construction | | | | | | | | | |
| Project year delay per vehicle mile without construction (min.) | | | 0.73 | | | 0.73 | | | 0.73 |
| Project year freeway traffic volume | | | 186,866 | | | 186,866 | | | 186,866 |
| Project year average vehicle occupancy | | | 1.33 | | | 1.33 | | | 1.33 |
| Project year average daily person hours of delay | | | 2,259 | | | 2,259 | | | 2,259 |
| Percent increase in delay during construction | | | 100% | | | 100% | | | 100% |
| Daily person hours of delay due to construction | | | 2,259 | | | 2,259 | | | 2,259 |
| No. of construction days | | | 250 | | | 250 | | | 250 |
| Total delay due to construction (person hours) | | | 564,694 | | | 564,694 | | | 564,694 |
| | | | | | | | | | |
| Change in external costs per mile | | | | | | | | | |
| Total corridor traffic change | | | 23,169 | | | 4,300 | | | (47) |
| Reasonable cost per VMT ( 6 cents /VMT) | | | 0.06 | | | 0.06 | | | 0.06 |
| Reasonable cost per mile | | | $1,390 | | | $258 | | | ($3) |
| | | | | | | | | | |
| Net Benefits per Mile | | | | | | | | | |
| Daily user mobility benefits | $49,171 | $0 | $49,171 | $17,260 | $39,009 | $56,269 | $21,197 | $40,295 | $61,492 |
| Other user benefits | $19,665 | $0 | $19,665 | $6,903 | $15,601 | $22,504 | $8,477 | $16,115 | $24,592 |
| Total daily user benefits | $68,836 | $0 | $68,836 | $24,163 | $54,610 | $78,773 | $29,674 | $56,410 | $86,084 |
| | | | | | | | | | |
| Daily external costs | | | $1,390 | | | $258 | | | ($3) |
| | | | | | | | | | |
| Net benefits daily | $68,836 | $0 | $67,446 | $24,163 | $54,610 | $78,514 | $29,674 | $56,410 | $86,087 |
| Number of days per year | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| Annual net benefits (million $) in Yr 2020 | $17.21 | $0.00 | $16.86 | $6.04 | $13.65 | $19.63 | $7.42 | $14.10 | $21.52 |
| Discount factor for 7% discount rate/30-year | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 |
| Present value of benefits for 30-year stream | $213.55 | $0.00 | $213.55 | $74.96 | $169.41 | $244.37 | $92.06 | $175.00 | $267.05 |
| | | | | | | | | | |
| Net benefits for project | | | | | | | | | |
| Number of added miles | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9 |
| Present value of benefits for 30-year stream | $1,922 | $0 | $1,922 | $675 | $1,525 | $2,199 | $828 | $1,575 | $2,403 |
| Costs of delays during construction ($ Mil.) | | | $71 | | | $71 | | | $15 |
| Present value of benefits (Mil.$) | | | $1,851 | | | $2,128 | | | $2,388 |

**TABLE 7. ESTIMATES OF BENEFITS AND COSTS FOR SOUTHERN SEGMENT**

| | Alternative 4 | | | Alternative 5 | | | Alternative 6 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GP | Toll | Total | GP | Toll | Total | GP | Toll | Total |
| Travel delay costs per mile during construction | | | | | | | | | |
| Project year delay per vehicle mile without construction (min.) | | | 0.73 | | | 0.73 | | | 0.73 |
| Project year freeway traffic volume | | | 186,866 | | | 186,866 | | | 186,866 |
| Project year average vehicle occupancy | | | 1.33 | | | 1.33 | | | 1.33 |
| Project year average daily person hours of delay | | | 2,259 | | | 2,259 | | | 2,259 |
| Percent increase in delay during construction | | | 100% | | | 100% | | | 100% |
| Daily person hours of delay due to construction | | | 2,259 | | | 2,259 | | | 2,259 |
| No. of construction days | | | 250 | | | 250 | | | 250 |
| Total delay due to construction (person hours) | | | 564,694 | | | 564,694 | | | 564,694 |
| Change in external costs per mile | | | | | | | | | |
| Total corridor traffic change | | | (1,024) | | | (4,559) | | | (9,936) |
| Reasonable cost per VMT ( 6 cents /VMT) | | | 0.06 | | | 0.06 | | | 0.06 |
| Reasonable cost per mile | | | ($61) | | | (274) | | | ($596) |
| Net Benefits per Mile | | | | | | | | | |
| Daily user mobility benefits | $23,241 | $37,072 | $60,313 | $26,413 | $38,239 | $64,653 | ($1,241) | $88,326 | $87,086 |
| Other user benefits | $9,295 | $14,826 | $24,121 | $10,563 | $15,293 | $25,856 | ($496) | $35,324 | $34,828 |
| Total daily user benefits | $32,535 | $51,898 | $84,434 | $36,976 | $53,532 | $90,509 | ($1,737) | $123,651 | $121,913 |
| Daily external costs | | | ($61) | | | ($274) | | | ($596) |
| Net benefits daily | $32,535 | $51,898 | $84,495 | $36,976 | $53,532 | $90,782 | ($1,737) | $123,651 | $122,510 |
| Number of days per year | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| Annual net benefits (million $) in Yr 2020 | $8.13 | $12.97 | $21.12 | $9.24 | $13.38 | $22.70 | ($0.43) | $30.91 | $30.63 |
| Discount factor for 7% discount rate/30-year | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 | 12.409 |
| Present value of benefits for 30-year stream | $100.93 | $161.00 | $261.93 | $114.71 | $166.07 | $280.78 | ($5.39) | $383.59 | $378.21 |
| Net benefits for project | | | | | | | | | |
| Number of added miles | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| Present value of benefits for 30-year stream | $908 | $1,449 | $2,357 | $1,032 | $1,495 | $2,527 | ($49) | $3,452 | $3,404 |
| Costs of delays during construction ($ Mil.) | | | $71 | | | $71 | | | $15 |
| Present value of benefits (Mil.$) | | | $2,286 | | | $2,456 | | | $3,389 |

TABLE 8. SUMMARY OF TRAVEL IMPACTS OF ALTERNATIVES

| | No Build | No 1<br>10 GP Ln | No 2<br>4 ET | No 3<br>4 E + BRT | No 4<br>4 HOT | No 5<br>4 H+ BRT | No 6<br>10 H + BRT |
|---|---|---|---|---|---|---|---|
| Total daily person trips in yr 2020 | | | | | | | |
| Segment 1 | 445,000 | 468,169 | 450,237 | 451,687 | 452,024 | 453,277 | 444,887 |
| Segment 2 | 460,000 | 483,148 | 464,721 | 466,144 | 466,474 | 467,709 | 459,227 |
| Segment 3 | 400,000 | 420,488 | 406,373 | 407,733 | 408,045 | 409,192 | 401,540 |
| Freeway daily vehicle trips in Yr 2020 | | | | | | | |
| Segment 1 | 280,299 | 312,210 | 288,765 | 285,494 | 284,761 | 282,117 | 269,465 |
| Segment 2 | 289,747 | 321,929 | 297,461 | 294,002 | 293,227 | 290,432 | 267,546 |
| Segment 3 | 251,954 | 280,306 | 262,263 | 259,382 | 258,733 | 256,378 | 275,223 |
| Yr 2020 **new** carpool person trips daily | | 0 | -358 | -2,573 | 26,868 | 22,808 | 6,672 |
| Yr 2020 transit trips daily | | | | | | | |
| Segment 1 | 8,900 | 8,900 | 9,990 | 16,739 | 9,539 | 15,763 | 16,231 |
| Segment 2 | 9,200 | 9,200 | 10,327 | 17,304 | 9,861 | 16,294 | 16,778 |
| Segment 3 | 8,000 | 8,000 | 8,980 | 15,047 | 8,575 | 14,169 | 14,590 |
| Total one-way trips at 10 miles per trip | 12,190 | 12,190 | 13,684 | 22,927 | 13,066 | 21,590 | 22,231 |
| New one-way trips | | 0 | 1,494 | 10,737 | 876 | 9,400 | 10,041 |
| Year 2020 transit user benefits | | | | | | | |
| Change in in-vehicle time per trip | | -7 | -15 | -30 | -15 | -30 | -30 |
| Change in out-of-vehicle time per trip | | 0 | 0 | -5 | 0 | -5 | -5 |
| Change in fare cost per trip | | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | -$2.00 |
| Total change in generalized cost per trip | | -$1.04 | -$2.25 | -$6.00 | -$2.25 | -$6.00 | -$8.00 |
| Transit rider consumer surplus daily | | $12,617 | $32,468 | $169,775 | $30,383 | $157,741 | $218,018 |
| Transit rider consumer surplus annually ($M.) | | $3.15 | $8.12 | $42.44 | $7.60 | $39.44 | $54.50 |
| Yr 2020 travel delay reduced daily (person hours) | | **104,212** | **119,142** | **130,095** | **127,683** | **136,790** | **298,920** |

**TABLE 9. SUMMARY OF FINANCIAL AND ECONOMIC IMPACTS OF ALTERNATIVES**

| | No Build | No 1<br>10 GP Ln | No 2<br>4 ET | No 3<br>4 E + BRT | No 4<br>4 HOT | No 5<br>4 H+ BRT | No 6<br>10 H + BRT |
|---|---|---|---|---|---|---|---|
| Gross annual revenues from tolls (mil.$) | $0 | $0 | $136 | $127 | $107 | $101 | $274 |
| Adjusted annual revenues from tolls (mil.$) | $0 | $0 | $136 | $127 | $107 | $101 | $246 |
| Yr 2020 highway costs (mil.$): | | | | | | | |
| Present value of highway costs | | $817.99 | $1,117.99 | $1,117.99 | $1,142.81 | $1,142.81 | $882.81 |
| Annual toll operations cost | | $1.38 | $8.02 | $8.00 | $6.38 | $6.42 | $21.00 |
| Annualized highway facility cost | | $65.92 | $90.10 | $90.10 | $92.10 | $92.10 | $71.14 |
| Total annualized highway costs | | $67.29 | $98.11 | $98.10 | $98.47 | $98.52 | $92.14 |
| Toll revenue surplus (for highways only) | | -$67.29 | $37.83 | $28.70 | $8.35 | $2.96 | $154.34 |
| Yr 2020 other mode costs(mil.$) | | | | | | | |
| Annual transit subsidy increase (mil.$) | | $0.00 | $2.68 | $19.30 | $1.57 | $16.90 | $18.05 |
| Annual cost for low fare service | | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $7.22 |
| Annual park-and-ride facility costs | | $0.00 | $0.37 | $2.68 | $0.22 | $2.35 | $2.51 |
| Total annual other mode costs (mil $) | | $0.00 | $3.06 | $21.99 | $1.79 | $19.25 | $27.78 |
| Annual costs for all modes | | $67.29 | $101.17 | $120.09 | $100.27 | $117.77 | $119.93 |
| Annual revenue surplus (for hwy/transit package) | | **-$67.29** | **$34.77** | **$6.71** | **$6.56** | **-$16.29** | **$126.56** |
| **Performance Measures** | | | | | | | |
| Present value of benefits (Mil.$) | | $3,966 | $4,611 | $5,580 | $4,939 | $5,690 | $7,742 |
| Present value of costs (mil. $) | | $835 | $1,255 | $1,490 | $1,244 | $1,461 | $1,488 |
| Net present value (mil. $) | | **$3,131** | **$3,356** | **$4,090** | **$3,694** | **$4,228** | **$6,254** |
| Yr 2020 travel delay reduced daily (person hours) | | 104,212 | 119,142 | 130,095 | 127,683 | 136,790 | 298,920 |
| Highway cost per hour of congestion delay reduced | | $2.53 | $3.02 | $2.77 | $2.89 | $2.69 | $0.95 |
| All mode cost per hour of congestion delay reduced | | $2.58 | $3.40 | $3.69 | $3.14 | $3.44 | $1.60 |
| Yr 2020 new transit person trips daily | | 0 | 1,494 | 10,737 | 876 | 9,400 | 10,041 |
| Transit costs per new transit trip | | N.A. | $8.19 | $8.19 | $8.19 | $8.19 | $11.07 |
| Yr 2020 **new** person trips accomodated | | 44,985 | 10,732 | 13,571 | 14,228 | 16,671 | 204 |

**TABLE 10. RESULTS OF SENSITIVITY ANALYSIS**

| | Base Assumptions | Demand Elasticity Tests High | Demand Elasticity Tests Low | Travel Time Value Tests High | Travel Time Value Tests Low |
|---|---|---|---|---|---|
| Assumed Travel Time Elasticity | -0.20 | -0.30 | -0.10 | -0.20 | -0.20 |
| Value of time (all lanes) | $9.00 | $9.00 | $9.00 | $13.50 | $4.50 |
| Min. value of time (ET lanes) | $13.00 | $13.00 | $13.00 | $19.50 | $6.50 |
| Min. value of time (HOT lanes) | $14.00 | $14.00 | $14.00 | $21.00 | $7.00 |
| Min. value of time (FAIR lanes) | $3.00 | $3.00 | $3.00 | $4.50 | $1.50 |
| **Base Case Travel Demand** | | | | | |
| Yr 2020 carpool person trips | 70,120 | 8.00% | | | |
| Yr 2020 transit person trips | 12,190 | 1.39% | | | |
| Yr 2020 total person trips | 876,500 | | | | |

| **RESULTS WITH BASE ASSUMPTIONS** | **No 1 10 GP Ln** | **No 2 4 ET** | **No 3 4 E + BRT** | **No 4 4 HOT** | **No 5 4 H+ BRT** | **No 6 10 H + BRT** |
|---|---|---|---|---|---|---|
| Min. value of time assumed for priced veh | $0.00 | $13.00 | $13.00 | $14.00 | $14.00 | $3.00 |
| Total annualized highway costs | $67.29 | $98.11 | $98.10 | $98.47 | $98.52 | $92.14 |
| Total annual other mode costs (mil $) | $0.00 | $3.06 | $21.99 | $1.79 | $19.25 | $27.78 |
| Annualized costs for all modes | $67.29 | $101.17 | $120.09 | $100.27 | $117.77 | $119.93 |
| **Travel demand estimates** | | | | | | |
| Yr 2020 **new** carpool person trips daily | 0 | -358 | -2,573 | 26,868 | 22,808 | 6,672 |
| Yr 2020 **new** transit person trips daily | 0 | 1,494 | 10,737 | 876 | 9,400 | 10,041 |
| Yr 2020 **new** person trips accomodated | **44,985** | **10,732** | **13,571** | **14,228** | **16,671** | **204** |
| Yr 2020 total person trips accomodated | 921,485 | 887,232 | 890,071 | 890,728 | 893,171 | 876,704 |
| Yr 2020 travel delay reduced daily (person hours) | 104,212 | 119,142 | 130,095 | 127,683 | 136,790 | 298,920 |
| **Financial estimates** | | | | | | |
| Adjusted annual revenues from tolls (mil.$) | **$0** | **$136** | **$127** | **$107** | **$101** | **$246** |
| Total annualized highway costs | $67 | $98 | $98 | $98 | $99 | $92 |
| Highway revenue surplus (or deficit) | -$67 | $38 | $29 | $8 | $3 | $154 |
| Total annual other mode costs (mil $) | $0 | $3 | $22 | $2 | $19 | $28 |
| All mode revenue surplus (or deficit) | -$67 | $35 | $7 | $7 | -$16 | $127 |
| **Economic and performance estimates** | | | | | | |
| Net present value (mil. $) | **$3,131** | **$3,356** | **$4,090** | **$3,694** | **$4,228** | **$6,254** |
| Yr 2020 travel delay reduced daily (person hours) | 104,212 | 119,142 | 130,095 | 127,683 | 136,790 | 298,920 |
| Highway cost per hour of congestion delay reduced | $2.53 | $3.02 | $2.77 | $2.89 | $2.69 | $0.95 |
| All mode cost per hour of congestion delay reduced | $2.58 | $3.40 | $3.69 | $3.14 | $3.44 | $1.60 |
| Avg. delay reduced per person trip (min.) | 6.8 | 8.1 | 8.8 | 8.6 | 9.2 | 20.5 |
| **SENSITIVITY ANALYSIS** | | | | | | |
| **Sensitivity to Assumed Travel Time Elasticity** | | | | | | |
| Increase by 50% to -0.3 | | | | | | |
| Yr 2020 new person trips accomodated | 59,730 | 13,641 | 17,239 | 18,074 | 21,188 | 328 |
| Adjusted annual revenues from tolls (mil.$) | $0 | $139 | $131 | $111 | $106 | $246 |
| Net present value (mil. $) | $2,671 | $3,260 | $3,975 | $3,569 | $4,087 | $6,265 |
| Reduce by 50% to -0.1 | | | | | | |
| Yr 2020 new person trips accomodated | 25,858 | 6,558 | 8,302 | 8,704 | 10,192 | 91 |
| Adjusted annual revenues from tolls (mil.$) | $0 | $131 | $121 | $101 | $95 | $247 |
| Net present value (mil. $) | $3,688 | $3,491 | $4,252 | $3,871 | $4,425 | $6,239 |
| **Sensitivity to Assumed Value of Travel Time** | | | | | | |
| Increase by 50% | | | | | | |
| Yr 2020 new person trips accomodated | 44,985 | 10,732 | 13,571 | 14,228 | 16,671 | 204 |
| Adjusted annual revenues from tolls (mil.$) | $0 | $204 | $190 | $160 | $152 | $370 |
| Net present value (mil. $) | $4,532 | $4,996 | $6,154 | $5,451 | $6,310 | $9,026 |
| Reduce by 50% | | | | | | |
| Yr 2020 new person trips accomodated | 44,985 | 10,732 | 13,571 | 14,228 | 16,671 | 204 |
| Adjusted annual revenues from tolls (mil.$) | $0 | $68 | $63 | $53 | $51 | $123 |
| Net present value (mil. $) | $1,730 | $1,715 | $2,026 | $1,938 | $2,147 | $3,481 |